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MEMORANDUM FOR PRS (Contractor Publication)

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SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-TP-1998-104**
Tim Miller (SPARTA) "Modeling of Interfacial Fracture in Photoelastic Specimens"
Vugraphs **(Statement A)**

File Name

Modeling of Interfacial Fracture in Photoelastic Specimens

T.C. Miller

Sparta, Incorporated

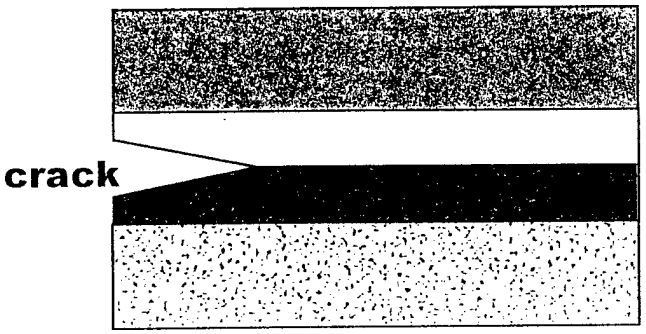
Air Force Research Laboratory

Edwards Air Force Base, California

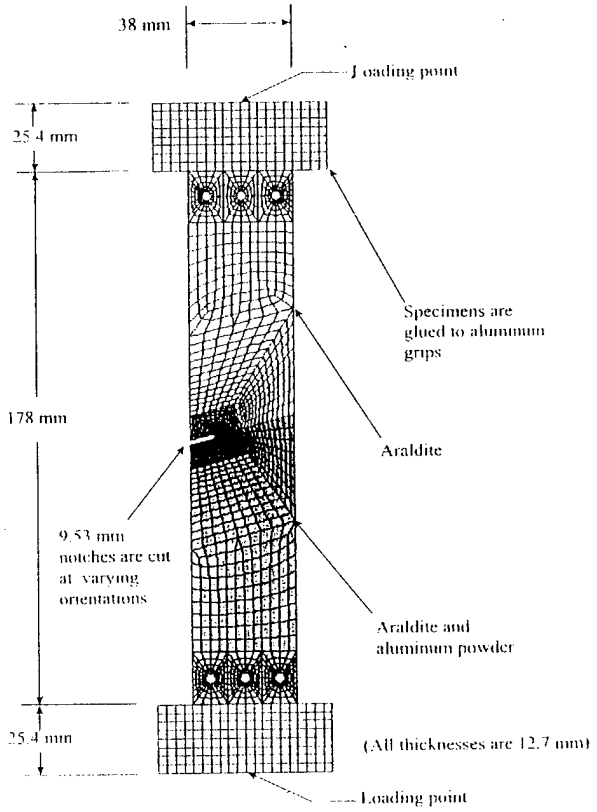
June 1998

Introduction

Applications to Composite Structures



Related Photoelastic Stress Freezing Experiments



Incompressible Bimaterial Paris Under Plane Strain Conditions

General Interfacial Fracture

$\epsilon \neq 0 \qquad \beta \neq 0$

$$\sigma_{pq} = \frac{1}{\sqrt{2\pi r}}\{Re(\boldsymbol{K} r^{i\epsilon})\Sigma^{I}_{pq}(\theta) + Im(\boldsymbol{K} r^{i\epsilon})\Sigma^{II}_{pq}(\theta)\}$$

$$(\sigma_{yy} + i\sigma_{xy})_{\theta=0} = \frac{\boldsymbol{K} r^{i\epsilon}}{\sqrt{2\pi r}} = \frac{K_1 + iK_2}{\sqrt{2\pi r}}[\cos(\epsilon Lnr) + i\sin(\epsilon Lnr)]$$

$$J = G = \frac{\Lambda_1 + \Lambda_2}{16\cosh^2(\pi\epsilon)}|K|^2$$

Plane Strain/Incompressible Materials

$\epsilon = 0 \qquad \beta = 0$

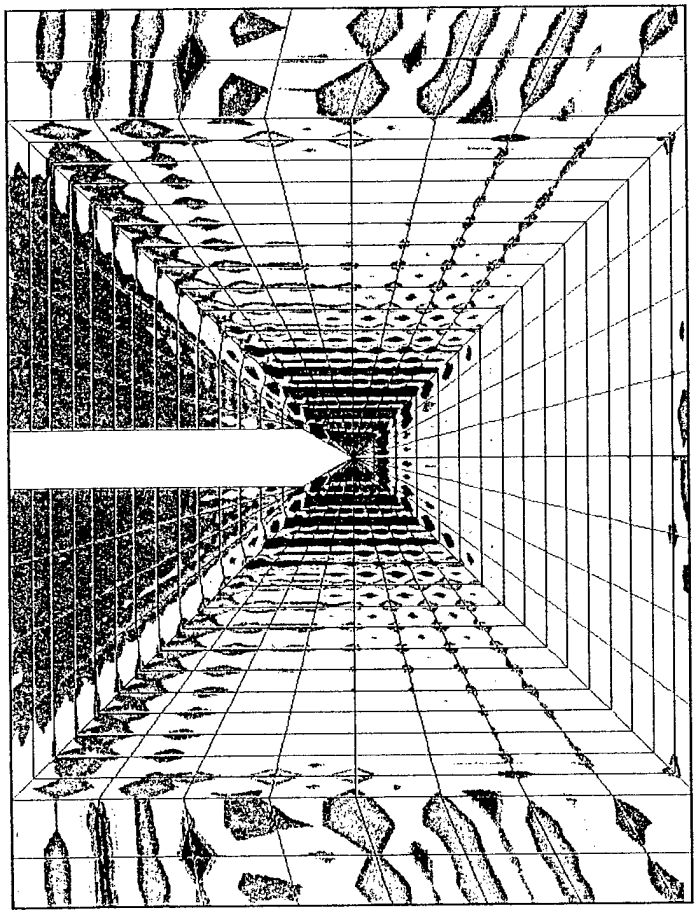
$$\sigma_{pq} = \frac{1}{\sqrt{2\pi r}}\{Re(\boldsymbol{K})\Sigma^{I}_{pq}(\theta) + Im(\boldsymbol{K})\Sigma^{II}_{pq}(\theta)\}$$

$$(\sigma_{yy} + i\sigma_{xy})_{\theta=0} = \frac{\boldsymbol{K}}{\sqrt{2\pi r}} = \frac{K_1 + iK_2}{\sqrt{2\pi r}}$$

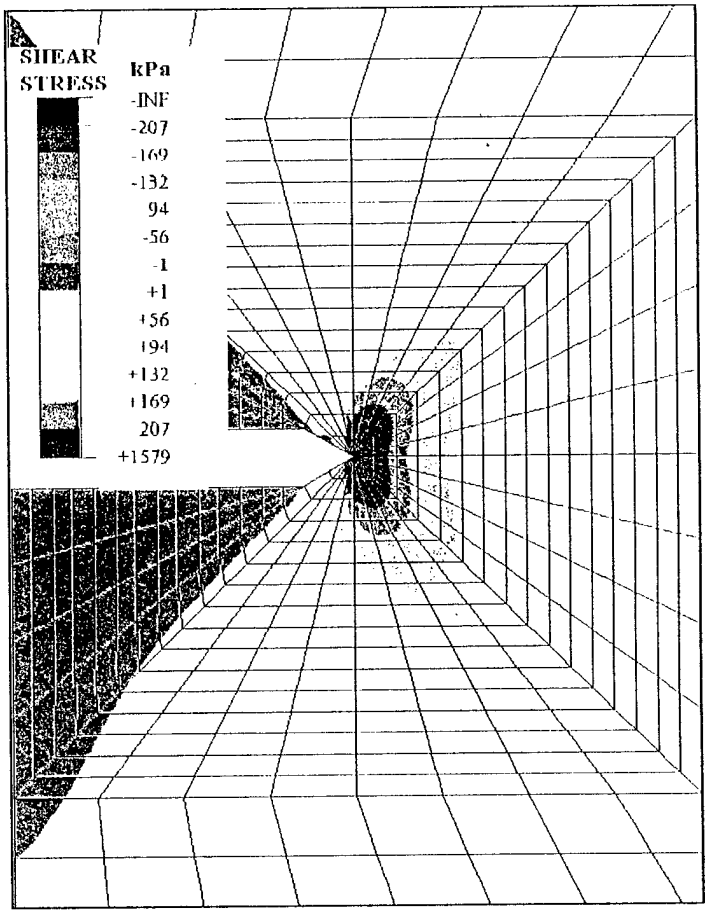
$$J = G = \frac{K^2}{\overline{E^*}}, \qquad \frac{1}{\overline{E^*}} = \frac{1}{2}\left[\frac{1}{\overline{E_1}} + \frac{1}{\overline{E_2}}\right], \qquad \overline{E_1} = \frac{E_1}{1-\nu_1^2}, \qquad \overline{E_2} = \frac{E_2}{1-\nu_2^2}$$

Hybrid Elements and Mixed Formulation Prevent Ill-Conditioning Problems

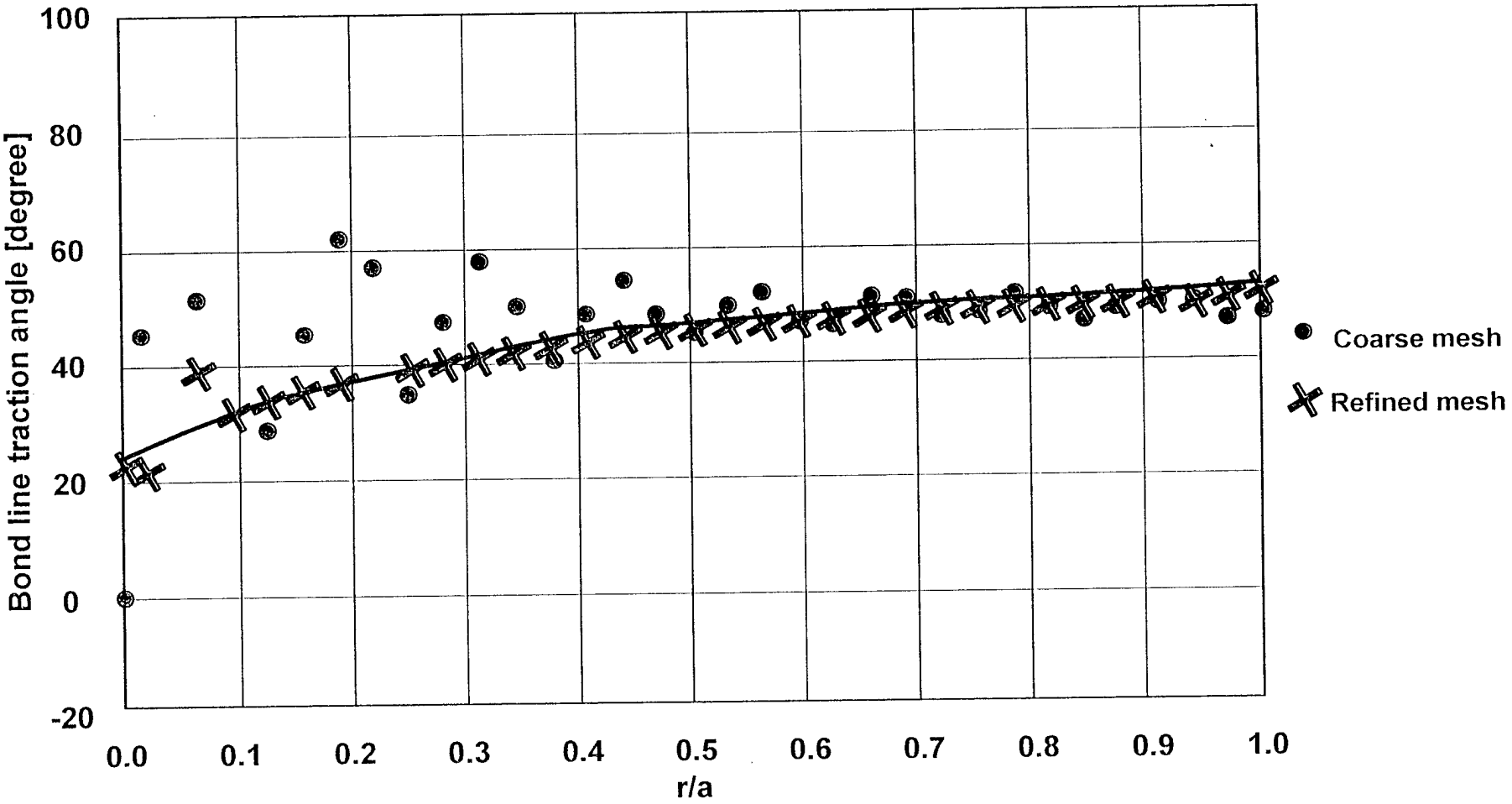
Conventional Formulation



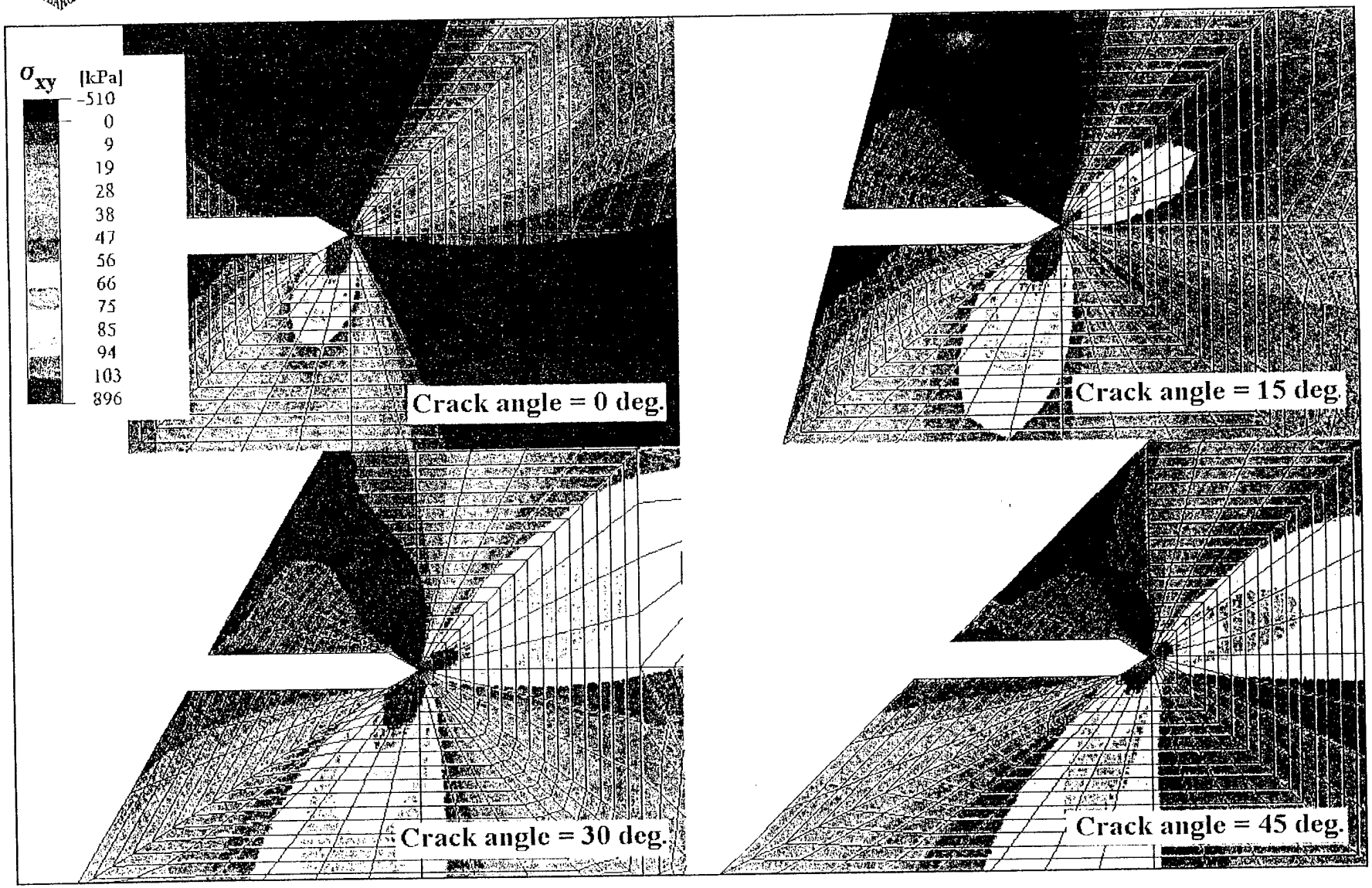
Mixed Formulation



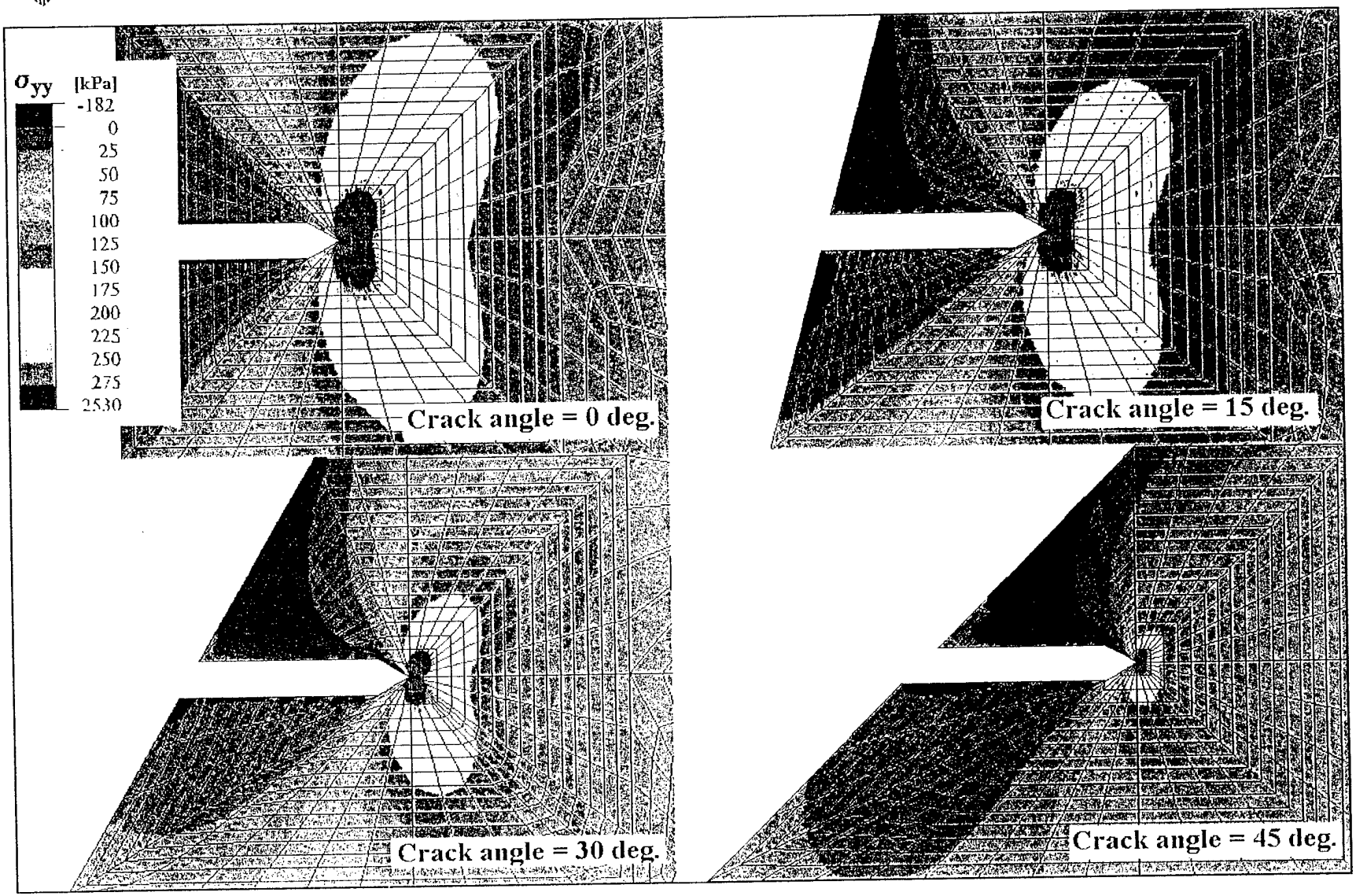
A Refined Mesh is Used to Provide Accurate Bond Line Tractions



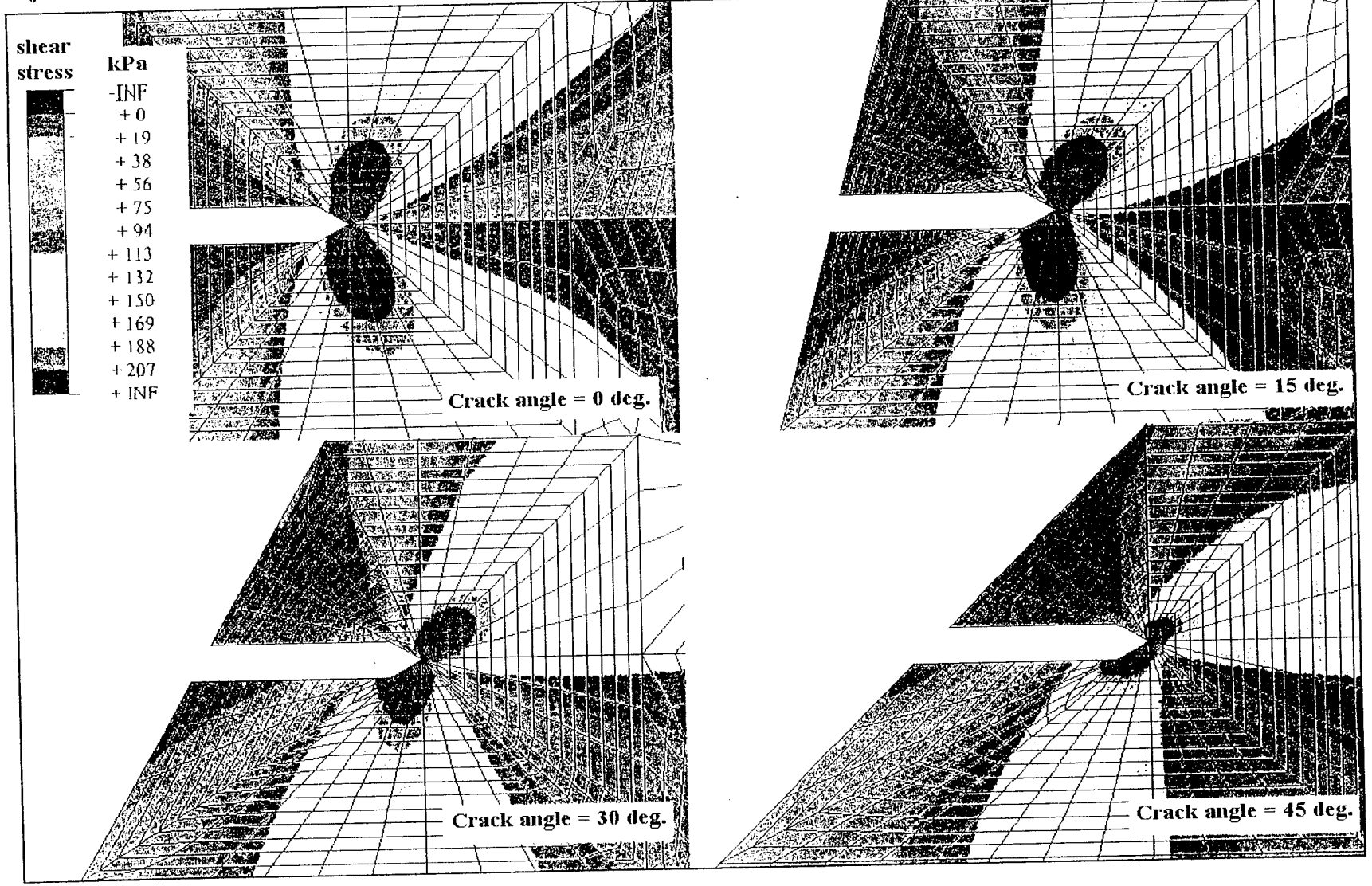
Contour Plots of In-Plane Shear Stress for Various Mode Mixities



Contour Plots of σ_{yy} Stress Component for Various Mode Mixities

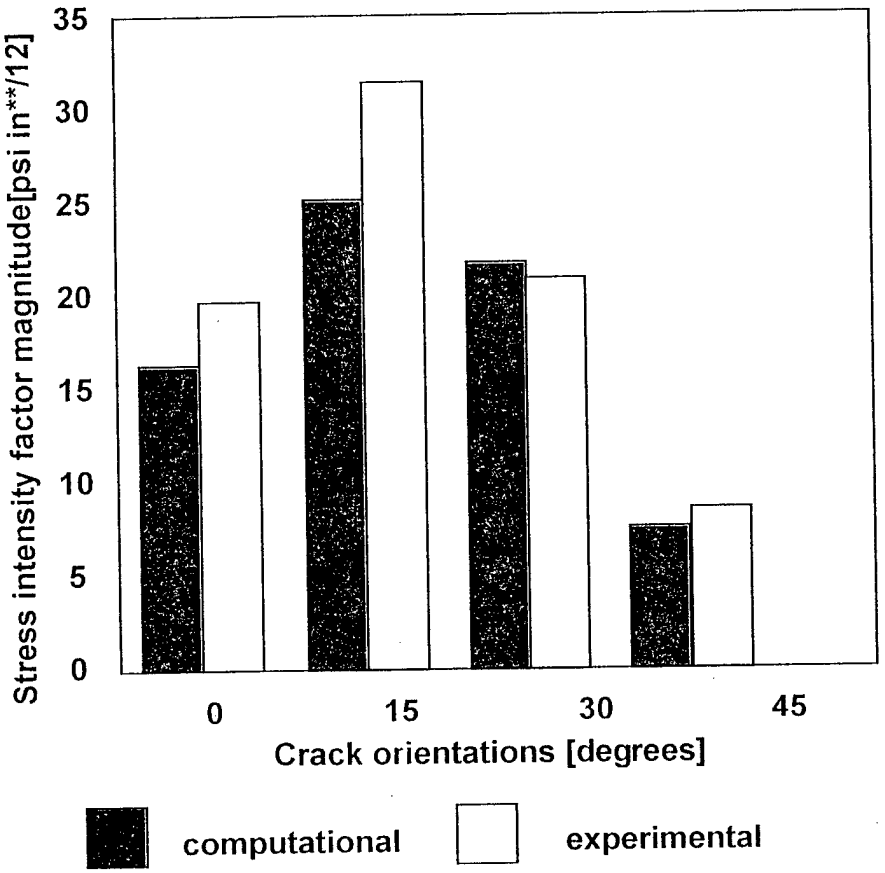


Contour Plot of Maximum In-Plane Shear Stress Component for Various Mode Mixities

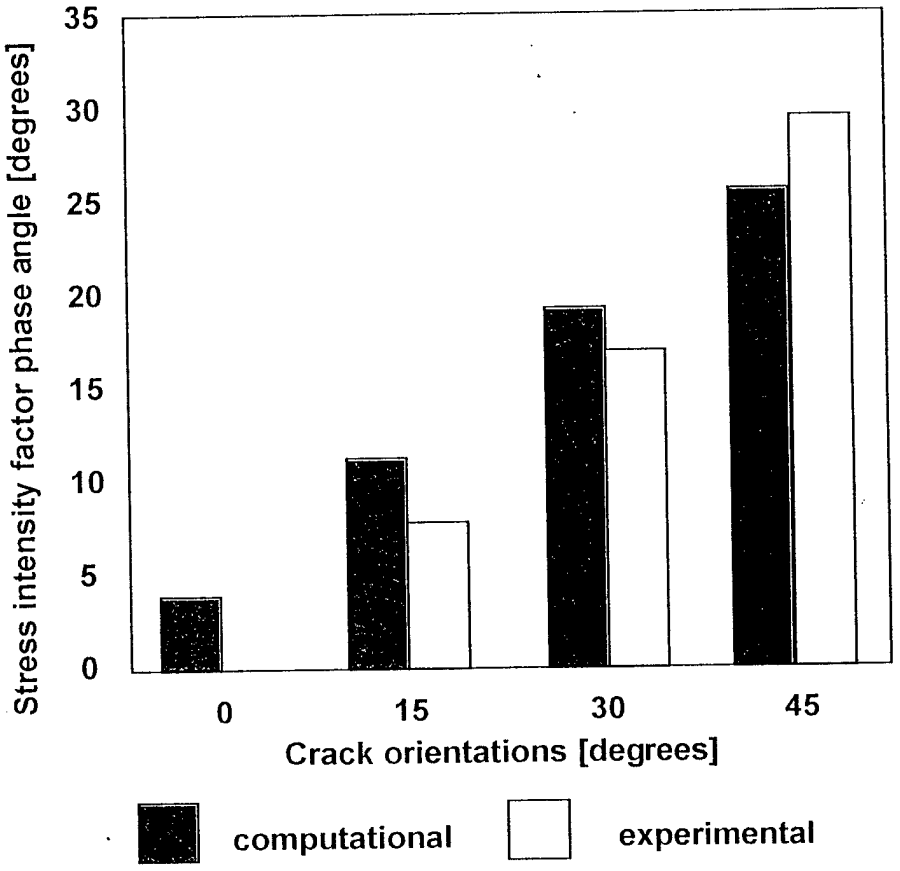


Results

Magnitude of Complex Stress Intensity Factors



Phase Angle of Complex Stress Intensity Factors



Conclusions

- Area integration and bond line traction regression is a simple and accurate way of determining the magnitude and phase angle of K for cracks along the interfaces between two incompressible materials under plane strain conditions.

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